Technical Research Note 227

ALPHA-NUMERIC VERSUS GRAPHIC DISPLAYS IN A PROBLEM-SOLVING TASK

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SUPPORT SYSTEMS RESEARCH DIVISION

BESRL

U. S. Army
Behavior and Systems Research Laboratory

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FOREWORD

Technological advancements have led to increased speed, mobility, and destructive power of military operations. To permit commanders to make tactical decisions consistent with rapid change and succession of events, information on military operations must be processed and used more effectively than ever before. To meet this need, the Army is developing automated systems for receipts, processing, storage, retrieval, and display of different types and vast amounts of military data. There is a concomitant requirement for research to determine how human abilities can be utilized to enable command information processing systems to function with maximum effectiveness.

BESRL's manned systems research in this area is directed toward the enhancement of human performance and facilitation of man-machine interaction in relation to total system effectiveness. It involves experimentation with various configurations of systems components, considering interactions and tradeoffs. The end products--immediate or ultimate--are scientific findings on human capabilities under varying conditions within the system. The findings have implications for systems design, development, and operational use. The present publication describes the evaluation, in terms of speed and accuracy, of two alternative modes of displaying information in an Army information processing system.

The entire research effort is responsive to requirements of RDT&E Project 2Q062106A723, Human Performance in Military Systems, FY 1972 Work Program, and to special requirements of the Assistant Chief of Staff for Force Development, the Assistant Chief of Staff for Intelligence, the U. S. Army Combat Developments Command and the U. S. Army Computer Systems Command.

J. E. UHLANER, Director
Behavior and Systems
Research Laboratory

ALPHA-NUMERIC VERSUS GRAPHIC DISPLAYS IN A PROBLEM-SOLVING TASK

BRIEF

Requirement:

To evaluate, in terms of speed and accuracy, alternative display modes for presenting information in an Army information processing system.

Procedure:

Two display modes, alpha-numeric and graphic, were compared as each interacts with two sets of system requirements: 1) need to base a decision on memory of information previously displayed versus no memory requirement, and 2) complexity of information to be held in memory (memory load).

Findings:

No clear-cut advantage in speed or accuracy was noted with either alpha-numeric or graphic displays when memory of displayed material was required. When memory was not required, alpha-numeric displays resulted in fewer errors of omission than did graphic displays, indicating that the display mode used in an information processing system may influence the relative proportions of different kinds of error made.

A secondary finding was that increasing complexity caused a deterioration in speed when no memory was required and a deterioration in accuracy when memory was required.

Utilization of Findings:

For speed and accuracy of decision making under a variety of memory requirements and complexity of information, either alpha-numeric or graphic displays may be used, depending on cost considerations and facilities available. When loss of information may reduce system effectiveness, results indicate a slight advantage to use of alpha-numeric displays. The extent of this advantage and the conditions under which it may occur can only be determined by closer examination of the relationship between display mode and type of error, especially where spatial manipulation of items of information is involved.

ALPHA-NUMERIC VERSUS GRAPHIC DISPLAYS IN A PROBLEM-SOLVING TASK

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ALPHA-NUMERIC VERSUS GRAPHIC DISPLAYS IN A PROBLEM-SOLVING TASK

BACKGROUND

To assist commanders and their staffs in the assimilation of tactical information, this information must be displayed in the most efficient manner possible. At present, information is displayed either in tables made up of arabic numerals and letters (alpha-numeric form) or on maps employing standard military symbols (graphic form).

Some effort has been made to determine the relative merits of these two forms of information display. In two BESRL experiments, the two display modes were compared in a military threat evaluation task. The subjects observed a series of displays containing three enemy forces. The composition and position of units within the three forces were updated at each presentation. Subjects were required to determine which of the three forces was most likely to attack, basing their decision on knowledge of enemy attack formations. While speed and accuracy of decision were related to rate of updating[1] and to time stress[2], in neither experiment were performance differences dependent upon mode of display.

In a non-military task, Howell and Tate[3] found graphic displays to be generally superior to alpha-numeric displays if subjects are required to recall the displayed material. Indirect support for graphic superiority has come from Newman and Davis[4] who found spatial coded material (graphic) to be superior to alphabetic coded material in both speed and accuracy of recall. Finally, Silver[5] found decision accuracy in a non-military task to be unrelated to display mode. Thus, comparisons of

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[1] Vicino, F. L. and S. Ringel. Decision making with updated graphic vs alpha-numeric information. Technical Research Note 178 (AD 647 623). Behavior and Systems Research Laboratory, Arlington, VA. November 1968.

[2] Green, C. Time stress and information format in a decision making task. Research Memorandum 68-4, Behavior and Systems Research Laboratory, Arlington, VA. April 1968.

[3] Howell, W. C. and J. D. Tate. Influence of display, response, and response set factors upon the storage of spatial information in complex displays. Journal of Applied Psychology, 1966, 50, 73-80.

[4] Newman, K. M. and A. R. Davis. Relative merits of spatial and alphabetic encoding of information for a visual display. Journal of Engineering Psychology, 1963, 1(3), 102-126.

[5] Silver, C. Development of criteria for evaluation of large-screen displays. (AD 621 231). August 1965.

performance with alpha-numeric and graphic displays have not conclusively favored either mode. This inconclusiveness suggests that the advantages or disadvantages of either display may be related to task requirements and characteristics of the information displayed. In the present research, both these relationships were examined with a long-term goal of suggesting the conditions under which alpha-numeric or graphic displays are preferable.

The bulk of the research on display modes deals with identification or recognition tasks. Yet in many systems--the Army's Tactical Operations System (TOS), for example--displays present information to be used as a problem-solving aid. A problem-solving task was therefore selected for the first experiment.

An obvious way in which alpha-numeric and graphic displays differ is in the symbols employed. Paivio[8] recently proposed the concept that verbal and image information are processed differently because the two types of information impose two distinct memory requirements. Assuming that verbal and image information correspond to alpha-numeric and graphic codes respectively, then display mode could be expected to interact with the memory requirements inherent in a task. To test this possibility, it was decided to compare alpha-numeric and graphic displays under different memory requirements.

At least two circumstances impose memory requirements on a field commander. First, a limited time to reach a decision may force a commander to use only his memory of previous information relevant to the problem. Second, the complexity of the information displayed may impose a severe memory load upon a commander. Memory load refers to the total number of different items of information which can potentially be present in the environment.

OBJECTIVES

The present experiment was designed to determine how alpha-numeric and graphic presentation affect performance under different system requirements. The long-term goal of the research is to generate a set of principles which can be used to determine which of the two display modes is optimal for a particular set of information processing requirements.

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[8] Paivio, A. Mental imagery in association learning and memory. Psychological Review, 1969, 76, 241-263.

The immediate objective of the experiment was to determine if the two display modes affect performance differentially for a range of memory requirements.

Stated specifically, the objectives were:

1. To compare alpha-numeric and graphic displays under task conditions which require either no memory or total memory for previous information.

2. To compare alpha-numeric and graphic displays under several levels of memory load where the load is determined by the total potential number of different units of information.

METHOD

Task and Apparatus

A series of problems constituted the basic task, each problem consisting of a table of organization for 80 units divided into three forces. A second table was provided which displayed the desired reorganization of the original forces. The goal was to write a sequence of orders to indicate which units must be moved and to what task force(s) to achieve the desired reorganization.

The stimulus material was displayed on 8" x 10" sheets. Problems were constructed by randomly assigning units to each of the task forces until the total of 80 units had been assigned. The three task forces were arbitrarily designated by the letters A, B, and C. Figures 1 and 2 are examples of equivalent problems in the alpha-numeric and graphic display modes, respectively.

The lower half of a problem sheet represents the desired reorganization and was constructed in the same manner as the top half. Figure 3 shows an alpha-numeric response sheet with the correct solutions circled as a subject might respond. For graphic displays, the three-letter abbreviations for unit type were represented by symbolic codes. The only other apparatus necessary was several Veeder-Groot timing devices[2].

Design

The three independent variables were Display Mode, Memory Requirements, and Complexity of Information.

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[2] Commercial designations are used only for precision in reporting and do not constitute indorsement by the Army or by BESRL.

INF	ARM	ART	ABN
BTN	BTN	BTN	BTN
BTN	BDE	BDE	REG
REG		BDE	REG
REG			BDE
DIV			

RAT	WAS	POL	AMO
BTN	REG	BDE	BTN
BTN	BDE	BDE	REG
DIV	DIV		BDE
	DIV		DIV

A

INF	ARM	ART	ABN
REG	BTN	BTN	BTN
BDE	REG	BTN	BTN
BDE	DIV	BDE	REG
	DIV	BDE	BDE

RAT	WAS	POL	AMO
BTN	BTN	BDE	BTN
BDE	REG	BDE	REG
BDE	REG	DIV	
DIV	BDE		
DIV			

B

INF	ARM	ART	ABN
DIV	BTN	BTN	REG
DIV	BTN	REG	BDE
	REG	REG	
		BDE	

RAT	WAS	POL	AMO
BTN	REG	BTN	BTN
DIV	REG	BTN	BDE
		BTN	BDE
		BDE	DIV
		DIV	

C

INF	ARM	ART	ABN
REG	BTN	BDE	BTN
REG	BDE	BDE	REG
DIV		BDE	REG
			BDE

RAT	WAS	POL	AMO
BTN	REG	BDE	BTN
BTN	REG	BDE	REG
DIV	REG		DIV
	BDE		
	DIV		
	DIV		

A

INF	ARM	ART	ABN
BTN	BTN	BTN	BTN
BTN	BTN	BTN	BTN
REG	REG	BTN	REG
BDE	DIV	BDE	BDE
BDE	DIV		

RAT	WAS	POL	AMO
BTN	BTN	BDE	BTN
BDE	REG	BDE	REG
BDE	BDE	DIV	BDE
DIV			

B

INF	ARM	ART	ABN
DIV	BTN	BTN	REG
DIV	REG	REG	BDE
		REG	
		BDE	

RAT	WAS	POL	AMO
BTN	REG	BTN	BTN
DIV		BTN	BDE
DIV		BTN	BDE
		BDE	DIV
		DIV	

C

Figure 1. Sample alpha-numeric display

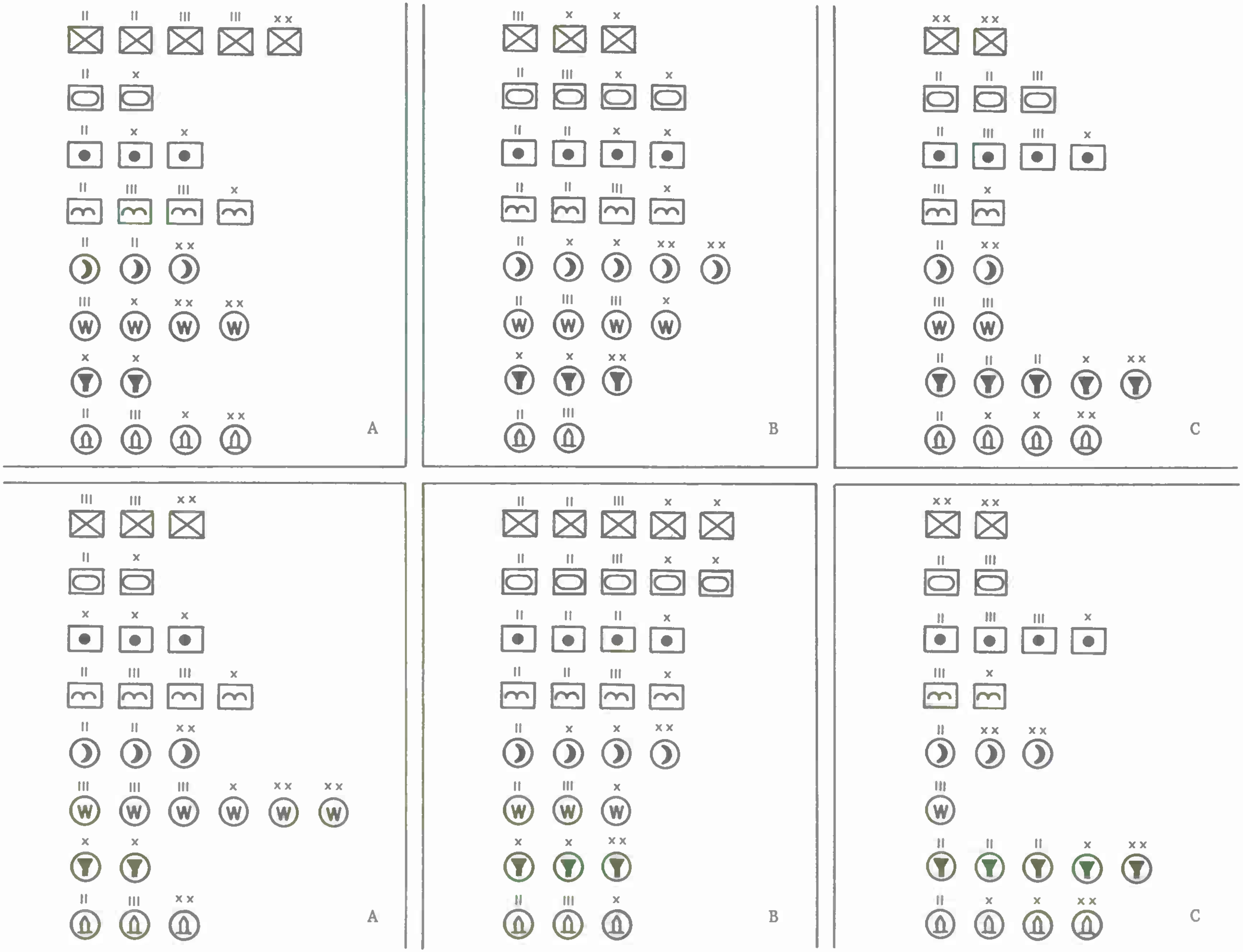

Figure 2. Sample graphic display

INF ARM ART ABW

1. 1 2 3 4 5 6 RAT WAS POL AMO BTN REG BDE DIV FM A B C TO A B C

INF ARM ART

2. 1 2 3 4 5 6 RAT WAS POL AMO BTN REG BDE DIV FM A B C TO A B C

INF ARM ART

3. 1 2 3 4 5 6 RAT WAS POL AMO BTN REG BDE DIV FM A B C TO A B C

INF ARM ART

4. 1 2 3 4 5 6 RAT WAS POL AMO BTN REG BDE DIV FM A B C TO A B C

INF ARM ART

5. 1 2 3 4 5 6 RAT WAS POL AMO BTN REG BDE DIV FM A B C TO A B C

INF ARM ART

6. 1 2 3 4 5 6 RAT WAS POL AMO BTN REG BDE DIV FM A B C TO A B C

INF ARM ART

7. 1 2 3 4 5 6 RAT WAS POL AMO BTN REG BDE DIV FM A B C TO A B C

INF ARM ART

8. 1 2 3 4 5 6 RAT WAS POL AMO BTN REG BDE DIV FM A B C TO A B C

Figure 3. Sample response sheet for one problem.

The first set of numbers refers to the number of units being moved. The abbreviations refer to type of unit (in the graphic problems the symbol is used). The letters A,B,C refer to the sector or task force from which a unit is moved and to which it is sent. The circled values represent the correct response to the problem presented in Figures 1 and 2.

Display Mode was either alpha-numeric or graphic. Standard military symbols and abbreviations were employed in both displays, with minor modifications in the alpha-numeric code to equate the abbreviations for length. Since the emphasis in the experiment was on developing general principles, the displays represented a somewhat abstract version of actual military displays.

Task requirements in terms of memory were represented by two conditions. In the No-Memory condition, the original and the desired task force displays were presented simultaneously until the problem was completed. In the Memory condition, the subject was presented the original task force display for study. Total study time was left to the discretion of the subject up to a maximum of ten minutes. When the subject indicated he was ready, the original task force display was removed and the subject was given the desired task force display and required to solve the problem using his memory of the original forces.

The four levels of Complexity were achieved by selecting three classes of information--combat units, supply units, and size of unit. Four items were then chosen within each of the three classes. Since each size designation could be combined with any of the combat or supply units, there were up to 32 different combinations of items. Table 1 lists the items used and Table 2 shows the resulting levels of complexity. In levels 1 through 3, at least one example of each possible item appeared on the display. In level 4, not all of the potential items were necessarily presented in a problem. The number of units to be moved was in the same range as in the lower level problems. The number of different items actually displayed in level 4 ranged from 24 to 32.

The complete design was then a 2 (Display Mode) x 2 (Memory Requirement) x 4 (Complexity) factorial. Display Mode and Memory Requirement were <u>between-subject</u> variables (Table 3). Complexity was a <u>within-subject</u> variable.

Subjects

The experiment exployed 80 enlisted men with a General Technical (GT) Aptitude Area score of 100 or above. The men were tested in groups of 3 to 6, and each group served for one day. There were four groups of 20 men each, one group being assigned to each experimental condition.

Procedure

Each man was randomly assigned to one of the four between-subject conditions. Each was given a brief training session to familiarize him with military symbols or abbreviations and the nature of the task. In addition, each worked a sample problem with the experimenter. The instructional period lasted approximately 45 minutes.

Table 1

ITEMS OF INFORMATION PRESENTED IN THE EXPERIMENTAL TASKS BY CLASS

Class	Items[a]
COMBAT	Infantry - INF
	Armor - ARM
	Artillery - ART
	Airborne - ABN
SUPPLY	Rations - RAT
	Water - WAS
	Fuel - POL
	Ammunition - AMO
SIZE	Battalion - BTN
	Regiment - REG
	Brigade - BDE
	Division - DIV

[a]SIZE designation may be combined with each of the COMBAT or SUPPLY units, but COMBAT and SUPPLY units cannot be combined. Thus, there could be INF BDE but no INF WAS.

Table 2

LEVELS OF COMPLEXITY IN EXPERIMENTAL TASKS

Complexity Level	Classes[a]	Number of Possible Combinations
1	COMBAT or SUPPLY	4
2	COMBAT and SUPPLY	8
3	COMBAT and SIZE <u>or</u> SUPPLY and SIZE	16
4	COMBAT, SUPPLY and SIZE	32

[a]The "or" alternatives specify alternative CLASSES or combinations of CLASSES. All such alternatives were employed in the experiment to counterbalance code difficulty across subjects, e.g., in Level 1, half the subjects would be shown COMBAT units and the remaining half SUPPLY units.

Table 3

BASIC EXPERIMENTAL DESIGN

Complexity Level	Alpha-numeric Display		Graphic Display	
	Memory	No-Memory	Memory	No-Memory
1	[a]$S_1 \ldots S_{20}$	$S_{21} \ldots S_{40}$	$S_{41} \ldots S_{60}$	$S_{61} \ldots S_{80}$
2	$S_1 \ldots S_{20}$	$S_{21} \ldots S_{40}$	$S_{41} \ldots S_{60}$	$S_{61} \ldots S_{80}$
3	$S_1 \ldots S_{20}$	$S_{21} \ldots S_{40}$	$S_{41} \ldots S_{60}$	$S_{61} \ldots S_{80}$
4	$S_1 \ldots S_{20}$	$S_{21} \ldots S_{40}$	$S_{41} \ldots S_{60}$	$S_{61} \ldots S_{80}$

[a]S_1 = First subject, etc.

At the termination of the instruction period, each subject received a notebook of test problems. Problems were grouped by complexity level in sets of four and five problems per level for the Memory and No-Memory conditions, respectively. Thus, subjects in the Memory condition received a total of 16 problems and those in the No-Memory condition received 20 problems. This procedure was adopted because of the restricted number of problems which could be completed in the Memory task within the allotted time.

Dependent Variables

Two primary dependent measures were obtained for each subject. The first was the percent of correct responses across all problems within a complexity level. The second was the median time to solve a problem within a complexity level. For the Memory condition, the median time spent studying the original display was also obtained.

An additional evaluative measure was obtained by dividing each subject's errors into two categories, omissions and commissions. Omissions consisted of errors due to failure to include a unit type which required movement. Commissions consisted of all other errors. In effect, a commission occurred when a unit was correctly selected but the number moved or the relocation was incorrect. For purposes of analysis, omission frequencies were converted to percents for each subject. Since omissions and commissions were complementary, it was not necessary to perform any analysis directly upon percents of commission errors.

RESULTS

Accuracy

An analysis of variance was performed on the percent correct scores. Significant differences were obtained for Memory, Complexity, and the Memory x Complexity interaction[9]. Figure 4 graphically depicts these results. See Table 4 for the analysis of variance summary. As expected,

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[9] A preliminary analysis of variance and Newman-Keuls test indicated that the General Technical Aptitude Area scores for subjects in the alphanumeric Memory group were slightly lower than those for the remaining groups. However, in none of the groups was there a significant Spearman rank-order correlation between either GT score and overall percent correct or between GT score and total time. Table A-1 (Appendix) lists the GT group means and correlation values. Thus, it was assumed that groups could be treated as initially equivalent in further analyses.

performance was poorer in the Memory task than in the No-Memory task. A Newman-Keuls test indicated that percent correct was statistically equivalent over all levels of complexity in the No-Memory condition, but decreased with greater complexity in the Memory condition. The exception was that complexity levels 3 and 4 did not differ significantly. The leveling off from complexity level 3 to 4 suggests that a performance floor had been reached at level 3 complexity.

Table 4

ANALYSIS OF VARIANCE SUMMARY TABLE FOR PERCENT CORRECT

Source	df	MS	F	P
Between _Ss_	79			
Display (D)	1	87.36	1.00	
Memory (M)	1	230501.92	524.41	.001
D x M	1	1326.82	3.02	
_Ss_ W. DM	76	439.55		
Within _Ss_	240			
Complexity (C)	3	11142.93	74.36	.001
C x D	3	279.90	1.87	
C x M	3	7729.83	51.58	.001
C x D x M	3	385.43	2.57	
C x _Ss_ W. DM	228	149.85		

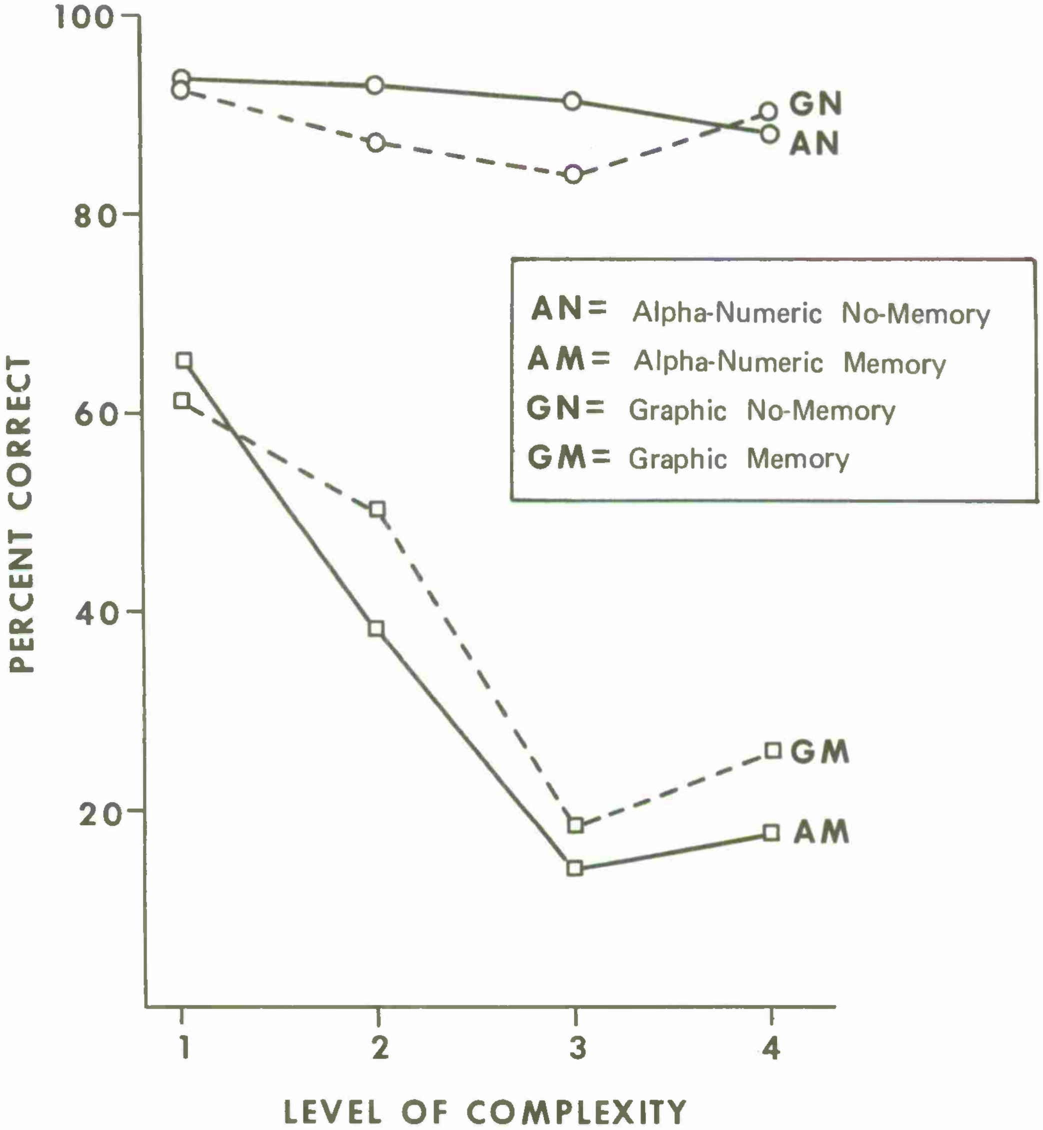

Figure 4. Percent correct responses as a function of complexity for each display x Memory condition

Speed

Analysis of variance of solution time revealed significant effects of Memory, Complexity, and a Memory x Complexity interaction (Table 5). Again, the men performed more poorly under the Memory condition. Solution time did not vary with complexity in the Memory task, but the results of a Newman-Keuls test showed increases from complexity levels 2 to 3 in the No-Memory task. These results are shown in Figure 5. Although solution time was not a function of complexity in the Memory condition, an analysis of variance performed on the time spent by subjects in studying the original displays indicated that study time did increase with Complexity (Table 6). Thus, if study time is added to solution time, the time spent on each problem varied directly with Complexity under both levels of Memory.

An analysis of variance was also conducted on percent omissions (Table 7). Memory, Complexity and the Display x Memory interaction proved significant. A Newman-Keuls test revealed the extent of these differences (Figure 6). Generally, percent omissions increased with complexity in all conditions, and was higher for the Memory than for the No-Memory task. The interaction is due to the lesser percent omissions occurring with the alpha-numeric display than with the graphic display in the No-Memory task. The difference vanishes in the Memory task. The interaction represents the only significant effect of Display which occurred in the experiment.

In summary, analysis of the percent correct and solution time scores showed that performance in the Memory task was consistently poorer than in the No-Memory task. However, in the No-Memory task, solution time increased as complexity increased while percent correct remained stable, whereas in the Memory task, percent correct decreased with increasing complexity while solution time remained constant.

In no case were percent correct and solution time affected by type of display employed. Examination of error type suggests that in the No-Memory task there were fewer omissions, hence more commissions, with an alpha-numeric display than with a graphic display. Since an omission represents an error in selection of unit type, there may be an initial encoding mechanism for unit type which is favored by alpha-numeric codes but which breaks down in a task involving a memory requirement.

Table 5

ANALYSIS OF VARIANCE SUMMARY TABLE FOR SOLUTION TIME

Source	df	MS	F	P
Between Ss	79			
Display	1	9867.90	1.00	
Memory	1	15010813.28	108.43	.001
D x M	1	424642.66	3.07	
Ss x DM	76	138431.46		
Within Ss	240			
Complexity (C)	3	1004381.96	20.31	.001
C x D	3	36385.73	1.00	
C x M	3	332157.37	6.72	.01
C x D x M	3	9674.18	1.00	
C x Ss W. DM	228	49452.41		

Table 6

ANALYSIS OF VARIANCE SUMMARY TABLE FOR STUDY TIME

Source	df	MS	F	P
Between Ss	39			
Display (D)	1	3779.14	2.37	
Ss W.D	38	1595.19		
Within Ss	120			
Complexity (C)	3	2002.49	4.63	.01
C x D	3	415.46	1.00	
C x Ss W.D	114	432.19		

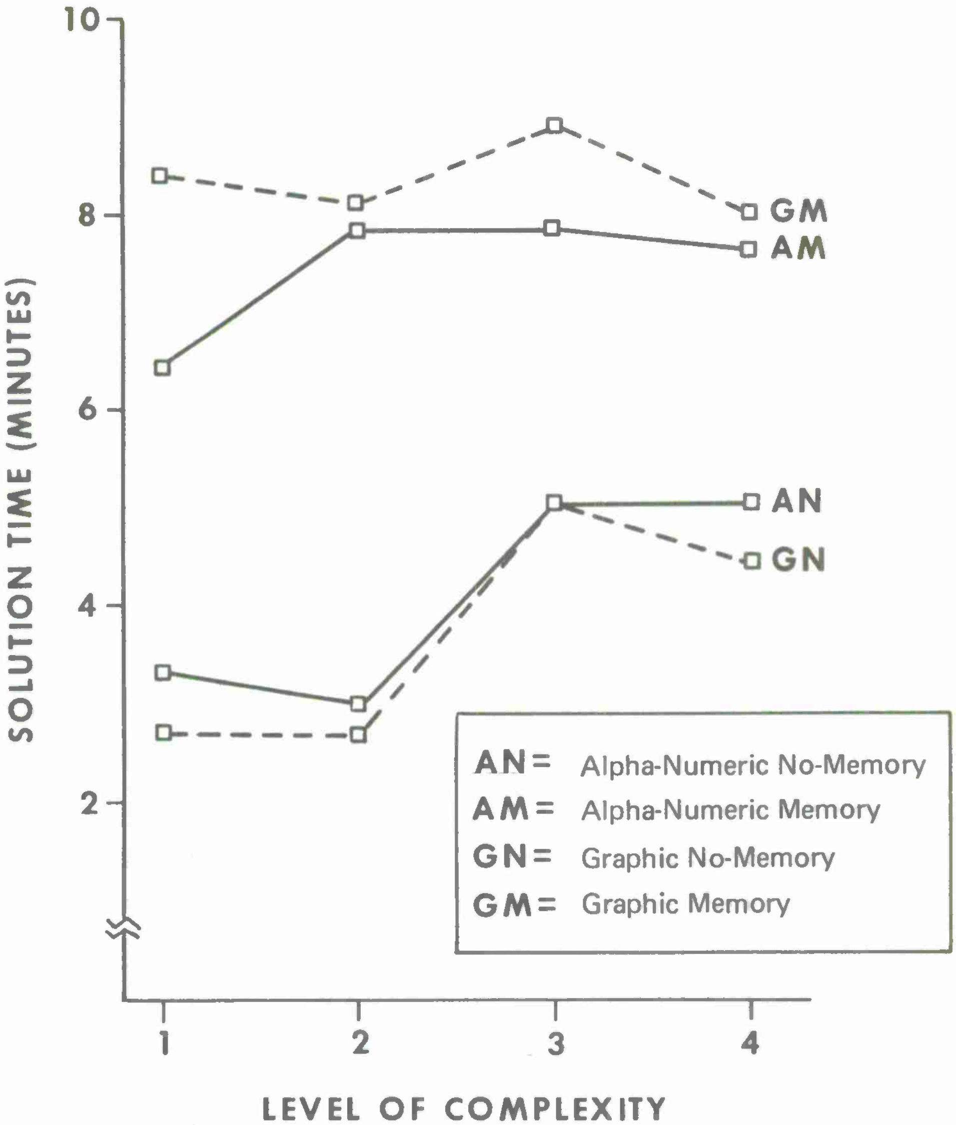

Figure 5. Solution time minutes as a function of complexity for each Display x Memory condition

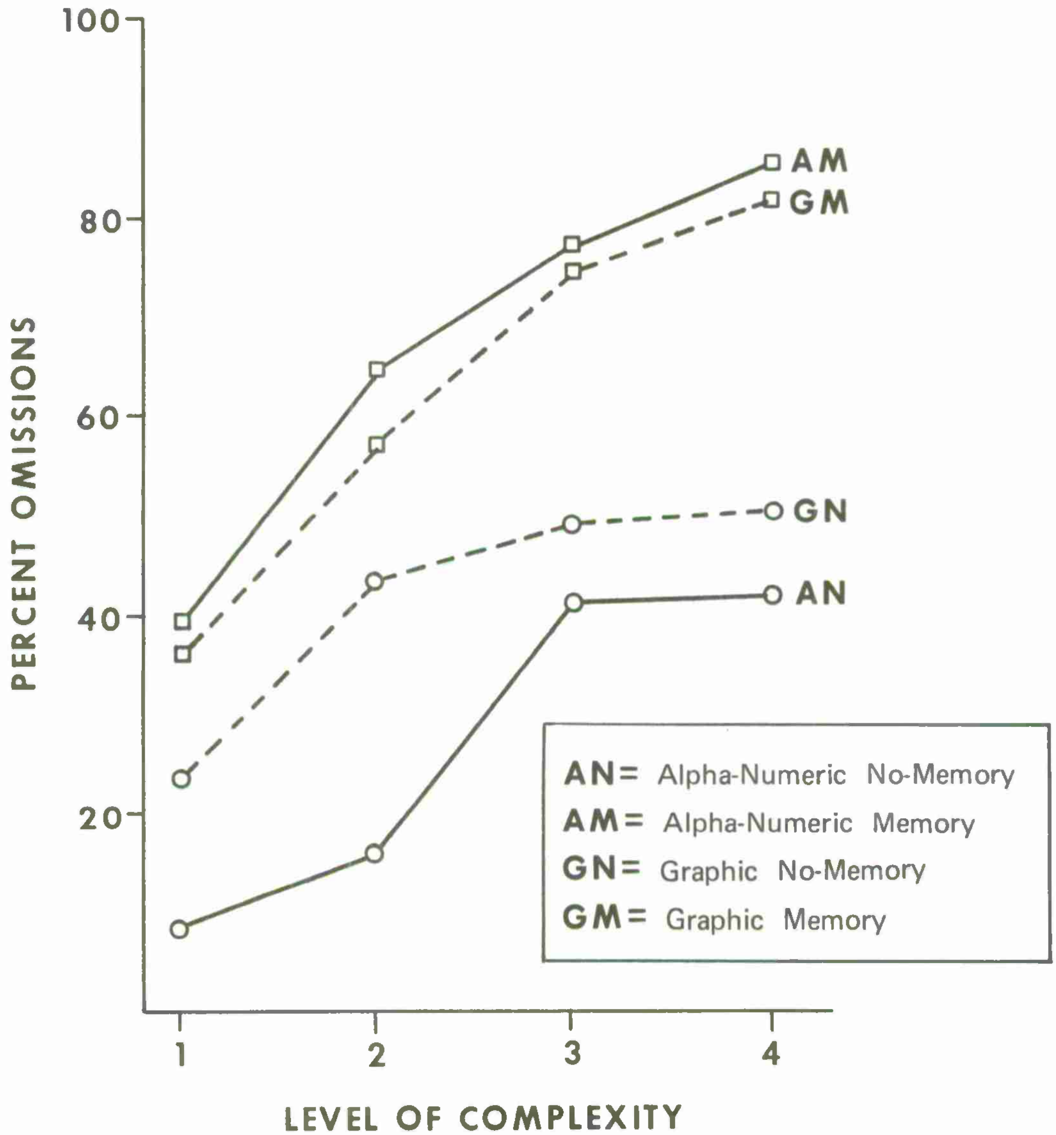

Figure 6. Percent omissions as a function of complexity for each Display x Memory condition

Table 7

ANALYSIS OF VARIANCE SUMMARY TABLE FOR PERCENT OMISSIONS

Source	df	MS	F	P
Between Ss	79			
Display (D)	1	2220.78	2.13	
Memory (M)	1	73841.63	70.73	.001
D x M	1	7536.90	7.22	.01
Ss W. DM	76	1043.96		
Within Ss	240			
Complexity (C)	3	23598.65	34.48	.001
C x D	3	234.04	1.00	
C x M	3	655.58	1.00	
C x D x M	3	852.45	1.24	
C x Ss W. DM	228	684.39		

IMPLICATIONS

Results of this research, in conjunction with previous research on the alpha-numeric versus graphic displays [1], [2], suggest that under a variety of tasks and conditions there is no clear-cut advantage to the use of either type of display. Hence, the choice of display type may be primarily one of cost consideration if time and accuracy are the primary determinants of system performance.

On the other hand, results of the analyses on the error data suggest that type of display employed may determine the kind of errors which are produced. If system output reflects the kind of errors which are produced, in addition to the amount of errors, then type of display mode employed may be of importance. In further research, the relationship between type of errors produced and display mode will be examined more closely. The present experiment minimized spatial-relational aspects within the task, requiring no spatial manipulation of information, as when terrain maps are employed. Additional research is under way to examine alpha-numeric and graphic displays in a task requiring the use of spatial relationships.

Finally, while a decrement in performance with increasing complexity is not surprising, complexity in the present task was related not to the absolute amount of information presented, but to the number of different elements of information. Thus, if many different kinds of information are available to the user, efficient methods of coding should be employed to distinguish clearly the different elements.

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[1] Vicino, F. L. and S. Ringel. Decision making with updated graphic vs alpha-numeric information. Technical Research Note 178. (AD 647 623). Behavior and Systems Research Laboratory. Arlington, VA. November 1968.

[2] Green, C. Time stress and information format in a decision making task. Research Memorandum 68-4. Behavior and Systems Research Laboratory. Arlington, VA. April 1968.

APPENDIX

Table A-1

ANALYSIS OF VARIANCE AND SPEARMAN RANK-ORDER CORRELATION
FOR GENERAL TECHNICAL APTITUDE AREA SCORES

Source	df	MS	F	P
Group	3	348.35	3.15	.05
_S_s W. Group	76	110.51		

Spearman Rank-Order Correlation Coefficients

	AN	AM	GN	GM
GT and Solution Time	+.21	-.04	-.05	+.04
GT and Percent Correct	+.22	-.12	-.23	+.24

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13. ABSTRACT

To assist commanders in making tactical decisions consistent with rapid change and succession of events, information on military operations must be processed and displayed in the most efficient manner possible. To meet this need, the Army is developing automated systems for receipt, processing, storage, retrieval, and display of different types and vast amounts of military data. At the same time, a requirement exists for research to determine how human abilities can be utilized to achieve the optimal functional effectiveness of information processing systems. BESRL's MANNED SYSTEMS research effort in this area is concerned with enhancement of human performance and facilitation of man-machine interaction in relation to total system effectiveness. Experimentation findings have implications for systems design, development, and operational use.

The experiment reported on here was designed to determine how alpha-numeric and graphic presentation affect performance, in terms of speed and accuracy, under two sets of system requirements: 1) need to base a decision on memory of information previously displayed versus no memory requirement, and 2) complexity of information to be held in memory (memory load).

Results of this study, in conjunction with previous comparative evaluation of the two alternative display modes, suggest that under a variety of tasks and conditions, there is no clear-cut advantage to the use of either alpha-numeric or graphic displays when memory of displayed material was required. Hence, the choice of display type may be primarily one of cost consideration if time and accuracy are the primary determinants of system performance. However, when memory was not required, alpha-numeric

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*Information display						
Intelligence information evaluation						
Decision making						
*Command information processing system						
Memory load						
Complexity of information						
Alpha-numeric display						
Graphic display						
Problem-solving task						
Military psychology						
Analysis of variance						

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13. ABSTRACT continued

displays resulted in fewer errors of omission than did graphic displays. It was also found that increasing complexity caused a deterioration in speed when no memory was required and a decrement in accuracy when memory was required. In further research, the relationship between type of errors produced and display mode will be examined more closely, especially in tasks where spatial manipulation of items of information is involved.